USGS

WATER RESOURCES RESEARCH GRANT PROPOSAL

Project ID: CT721

Title: A Characterization of the Discontinuous Nature of Kriging Digital Terrain Models

Focus Categories: Hydrology, Geomorpological and Geochemical Processes

Keywords: hydrology, continuity, runoff, gradient, slope, surface interpolation, surface modeling, kriging digital terrain modeling

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Abstract

Hydrology and surface runoff models depend extensively on digital terrain models (DTM) from which terrain gradients are derived. Surface gradients determine the potential energy available to drive surface flow and is considered by some researchers (Evans 72) to be the most important of all geomorphometrics. Given its critical role in hydrological modeling, it is imperative that hydrologists understand the continuity characteristics of the DTM being employed. The continuity of the DTM is an important contributor to interpolated gradient values, potentially effecting potential energy estimates as well as flow direction. Kriging (Matheron 63, Journal 78, David 77, Goovaerts 97) is a popular choice for the surface interpolation technique used with digital terrain models (DTMs). Bailey (94) asserts that ``there is an argument for kriging to be adopted as a basic method of surface interpolation in GIS as opposed to the standard deterministic tessellation techniques which currently prevail and which can produce artificially smooth surfaces." This argument was discussed in more detail by Laslett (94) who showed that although kriging is mathematically equivalent to minimal energy splines, his study gives an example of a data set for which splines are ``too smooth" and kriging results in more precise estimations. While kriging is not without its critics (Philip and Watson 86a), there is no question that its use is widespread.

In general, the properties of a mathematical surface being used as a terrain model define the properties imbued to the model. The onus is on the modeler to choose the mathematical surface wisely so that the properties of the surface give the desired traits of the terrain. Continuity properties are of paramount importance. Discontinuous surfaces have ``holes" or ``tears" in them, so to speak, creating fictitious nickpoints (i.e., waterfalls), and zigzagging and broken contour lines. Also, even if a surface were continuous, it might not be altogether smooth, meaning that the surface might have ``creases" in it effecting gradient estimations and flow direction. It is important to catalogue continuity properties and this project will establish these properties for surfaces created with kriging interpolation.

We will show that DTMs based on kriging are piece-wise discontinuous (zero-order) and then characterize bounds for the discontinuities. We will also determine if there is a correlation with prominent geomorphometrics such as slope, aspect, and roughness. Our goal is to enrich the understanding of

hydrologists as to whether kriging provides an acceptable DTM for their purposes. By providing information about the kind and severity of discontinuities one can expect, hydrologists are better equipped to choose among the many types of DTMs currently available for hydrological modeling.

This is basic research, exploring the mathematical properties of kriging, a widely-used surface interpolator. We focus our attention on the continuity properties of kriging digital terrain models exhibited over a wide range of terrain types. Our goal is to enrich the understanding of hydrologists as to whether kriging provides an acceptable DTM for their purposes. By providing information about the kind and severity of discontinuities one can expect, hydrologists are better equipped to choose among the many types of DTMs currently available for hydrological modeling.